NOVA UPDATE
OCTOBER–DECEMBER 1998

Nova Operations performed 216 experiments, which surpassed our goal for the quarter. These experiments supported efforts in Inertial Confinement Fusion (ICF), Defense Sciences, university collaborations, Laser Science, and Nova facility maintenance.

The process of planning the decommissioning of the Nova facility continued. In December, a notice appeared in the *Commerce Business Daily* to advertise the availability of Nova components. After the February 1999 deadline for proposals, a committee organized by the Department of Energy will determine the disposition of Nova components. It has already been decided that parts of Nova will be reused in the National Ignition Facility (NIF). For example, inspections have indicated that the FR5 rotator glass in the Nova Faraday rotators meets the specifications required for use on NIF.

The Petawatt project continued to innovate with the installation of a preformed plasma beamline. The center 15 cm of Beamline 8, which is unused by Nova, is already being used as a 4ω probe in the ten-beam target chamber. Hardware was installed in December that will permit this beam to be diverted to the Petawatt target chamber to create a preformed plasma in which the Petawatt beam will interact.

Hardware was installed and tested to allow the use of cryogenic targets in the Nova ten-beam target chamber for equation-of-state experiments that will be conducted next quarter. The ten-beam experiments will follow the two-beam cryogenic campaign, which served to map out the single-shock Hugoniot for deuterium from 200 kbar to 3 Mbar. The NIF will use multiple shocks to compress the hydrogen fuel to much higher density than can be achieved with a single shock, and there is no fundamental theory that allows us to calculate a priori what shock compression will be achieved for a given drive. In the cryogenic ten-beam experiments, we are developing diagnostic capability to tune multiple shocks for NIF ignition implosions and measuring the equation of state of hydrogen after two shocks. We are also simulating the plasma conditions that will occur in a NIF hohlraum with cryogenic dense He–H gas.

National Ignition Facility Update October–December 1998

Overall Assessment

Overall progress on the NIF Project remains satisfactory for the first quarter of FY99. The current top-level assessment of Project status remains similar to that stated at the end of the fourth quarter 1998: that there will be no change to the fourth quarter 2001 Level 2 milestone for the End of Conventional Construction, nor to the fourth quarter 2003 Project Completion date. However, the NIF Project Office now anticipates that based upon the status of Conventional Facilities, CSP-4, work on the Laser Bay Core, and the status of Special Equipment design and procurement, there could be an impact of 6 to 8 weeks in the fourth quarter 2001 completion of the Level 4 milestone for start-up of the first NIF bundle. The impact of current field conditions on this important milestone, which is to be completed in three years, continues to be evaluated on a weekly basis.

The first quarter 1999 was a productive quarter on the NIF site as the total Conventional Facilities work completed approached 42%. With the completion of Phase I work by Nielsen Dillingham Builders (NDBI), CSP-4, in December, the coordination between prime subcontractors on site has been reduced significantly. Hensel Phelps (CSP-9) now has unrestricted access and sole occupancy of the Laser Building. NDBI (CSP-6/10) has sole possession of the Target Building, and NDBI (CSP-5) has sole possession of the Optics Assembly Building (OAB). Coordination of access to the work areas, laydown space, and coordination of interface between subcontractors in the OAB Corridor are now the focus of the overall site coordination.

In Special Equipment, overall progress is satisfactory. Ten 100% reviews were conducted in the quarter, bringing the total percentage complete to 89%. In addition to the ongoing work to close out the Special Equipment design reviews and the continuation of procurement efforts, an expanded effort has been under way in the planning area. The primary focus is improving the ability to summarize the Integrated Project Schedule (IPS), providing easier methods to focus on particular areas or functions, and validating the installation logic. In addition, all Special Equipment procurement contract awards greater than $100K in the NIF Planning System must have equivalent contract milestones in the IPS. The Special Equipment part of the IPS has been reviewed and updated to ensure this compliance.

In Optics, facilitization is complete at Hoya and Schott with all contracts placed and pilot activities already started. Hiring and training for pilot runs is mostly completed. Both laser glass vendors are doing a great job in supporting the NIF schedules. The Zygo facility was completed in first quarter 1999 and first-bundle optics (LM3) are now being shaped. Pilot production contracts were finalized at two potassium dihydrogen phosphate (KDP) vendors and the first pilot runs were started, and six 1000-L crystallizers continued to operate at Lawrence Livermore National Laboratory (LLNL).

Key Assurance activities to support the Project are all on schedule, including construction safety support, litigation support to the Department of Energy (DOE) for the settlement of 60(b) (e.g., quarterly reports), and the *Final Safety Analysis Report* (FSAR).

At the end of FY98 there were 10 of 95 DOE/OAK (Oakland Office) Performance Measurement Milestones remaining to be completed, and by the end of first quarter 1999, were completed. The only remaining FY98 milestone is the "Cooling Towers Operational," which will be accomplished, as projected last quarter, in March 1999.

The FY99 DOE/OAK Performance Measurement Milestone plan includes 124 milestones. In the first quarter 1999, 11 milestones were due, and seven were completed. The cumulative variance for FY99 is four milestones. It is anticipated that two of the open first-quarter 1999 milestones will be completed in January and the remaining two in February.

In Special Equipment, three 100% reviews were conducted in October including Alignment Control, Target Area Alignment, and Final Optics Assembly. Two 100% reviews were conducted in November, including Wavefront Control Systems and Roving Mirror Diagnostic Enclosure. Five 100% reviews were conducted in December including Electronic Rack Cooling, Timing System, Pulse Generator Alignment, Precision Diagnostics, Laser Optics Damage Inspection, Roving Mirror and Roving Assemblies.

Table 1 lists Engineering Change Requests (ECRs) that were resolved by the Level 4 and Level 3 Change Control Boards during the quarter. No ECRs were over $250K. The cost impact of these ECRs and all other changes (i.e., Cost Transfer Requests) are reported in the change log at the end of each quarter. Schedule impacts are described in the individual ECRs. There are no impacts to any Level 0, 1, 2, 3 milestones.

In system integration, the following accomplishments were achieved during the first quarter 1999.

- Final preparations were completed for the design review of the rack cooling system in December, and detailed preparations began for the overall cable plant design review. Development of interface control documents (ICDs) defining cable plant requirements made some progress, but was not completed as required. Preparations for procurement of electrical racks and cable plant also continued.
- Precision Survey staff is completing the applicable Design Basis Book templates in preparation for the design review. Working reviews have been scheduled to review the draft and final viewgraphs and Design Basis Book inputs. Integrated Contractor Orders (ICOs) are being placed with Argonne, Fermi, and Lawrence Berkeley to fund their attendance and participation in the review. Stanford Linear Accelerator Center (SLAC) is already funded under an existing ICO.

TABLE 1. ECRs resolved by the Level 4 and Level 3 Change Control Boards during the first quarter 1999.

ECR	Title	Resolution
325	Replacement of TBD in Angular Positioning	Approved
337	Increase Size of TB Fire Sprinkler Ring	Approved
298	SDR 003 Title II Update	Approved
209	SSDR 1.8.7 Rev. D from C - FOA	Approved
344	SSDR Changes for Beam Control and Laser Diagnostics	Approved
376	Additional Laser Bay Embedded Grounding Plate	Approved
402	Revise Conduit Routing to MOR Panel	Approved

- All cable tray design and length drawings for the Laser Bays are complete except for the preamplifier support structure (PASS) area. These drawings are being recorded in the Project Database Management (PDM) system. The PASS structure area design effort began in December. Switchyard cable trays for 0′0″, 50′, and –21′9″ levels are complete. The 7′10″ level has been completely modeled to determine possible interference problems, but final tray layouts have not been completed.
- The Special Equipment rack cooling Design Review was presented in December. Comments and considerations offered at the Design Review are being discussed, and points of concern are being addressed. Heat exchanger fans have been ordered for planned lifetime tests. Reliability, availability, and maintainability (RAM) analysis efforts have begun to determine the reliability figures for the overall design. A letter of intent has been mailed to five vendors; no responses have been received at this time.

Site and Conventional Facilities

Despite the holidays, December was another busy and productive month on the NIF site as the total Conventional Facilities work completed approached 42%.

With the completion of Phase I work by NDBI, CSP-4, in December, the coordination between prime subcontractors on site has been reduced significantly. Hensel Phelps (CSP-9) now has unrestricted access and sole occupancy of the Laser Building. NDBI (CSP-6/10) has sole possession of the Target Building, and NDBI (CSP-5) has sole possession of the OAB. Coordination of access to the work areas, laydown space, and coordination of interface between subcontractors in the OAB Corridor are now the focus of the overall site coordination.

The decision to close up the hold-opens along grid 28 and at the capacitor bays, after the laser bay mat slabs are poured, will allow a significant amount of work to be completed this winter that was originally scheduled for next winter. Most of the girts and siding, plenum wall, and rack piping work can now be completed before turning each laser bay over to Special Equipment forces.

The Laser Building core continues to be the area of the project where the schedule delays are the major concern. The cast-in-place concrete walls and roof in the core from Grid 12 to 14 are scheduled to be completed in January (see Figure 1.) The installation of the air handlers between Grid 12 and 14 are the first units that must be placed in the Laser Building, and until these units are placed, the remaining units cannot be installed. Unfortunately, these air handlers contain the largest fans, which to date have not met the specified requirements for vibration testing.

Laser Bay 2 overhead and underground work has progressed well and is basically back on schedule. Laser Bay 1 is getting off to a slow start but should be completed faster than originally planned based on the experience from Laser Bay 2. Capacitor Bay 4 slab on grade placement and fine grading of Capacitor Bay 2 and 3 slabs were completed in December, which will open up significant areas for overhead rough-in to start. The building is dried-in to the extent possible considering the hold-opens required, and the site is ready for the upcoming winter weather.

FIGURE 1. Reinforcing for the concrete walls in the Laser Building mechanical mezzanine. (40-60-1198-2218#5Apb01)

The OAB is on schedule (see Figure 2), and the variances in the Target Building will be remedied when NDBI concentrates its resources on the critical areas of the building.

Laser Systems

The past quarter represents a shift in the emphasis for most of Laser Systems from design to procurement. Several large procurement actions were initiated (Frame Assembly Units [FAUs] and plasma electrode Pockels cell [PEPC] assembly fixture), and documentation was prepared for numerous others (flashlamps and main capacitor charging supplies, for example). Subsystem prototype testing continued to provide valuable information for value engineering and procedure development as well as design validation. Detailed planning documentation was completed for FY99.

- Oscillator stability measurements at the input to the Regenerative Amplifier were completed using prototype optical pulse generation (OPG) hardware. The results show an rms instability of 3.1%, compared with 5% required. However, these tests do not include the smoothing by spectral dispersion (SSD) modulator, which is expected to increase the instability. The high-frequency variations are due to the unstabilized laser relaxation oscillations as well as contributions from other components. A feedback control loop is being fabricated to suppress these. The low-frequency variation is a result of several sections of polarization-maintaining fiber in the system that have a polarization-state temperature dependence. This slow variation will be minimized with the polarizing fiber system in the design for the NIF. This prototype oscillator system has been used during the past quarter to conduct integrated tests including the oscillator and preamplifier module (PAM). The PAM was operated over a range of output energies spanning 0.07 to 22.1 J in a spatially shaped beam. This surpasses the energy performance requirements for the NIF system. Future tests will include SSD, steady-state operation, and demonstration of the temporal pulse-shaping capabilities of the integrated Master Oscillator Room (MOR)/PAM system. The drawings for the long-lead preamplifier beam transport components were completed and checked during the past quarter and are in the process of being procured for the integrated testing scheduled for late this calendar year.
- The amplifier effort remained on schedule during the first quarter of the Title III effort. Two large amplifier procurements were issued for bids in November as planned: frame assembly units (FAUs) and the Euclid alignment system. Bids are currently under evaluation for the FAU procurement. The amplifier team has also made progress in developing an improved correlation between observed cleanliness levels in the amplifier and component processing. This effort will lead to improved cleanliness procedures and component cleanliness specifications for the NIF amplifier.
- The PEPC assembly fixture was procured during the past quarter, and the parts have arrived at LLNL. The fixture will be assembled for functional tests beginning in January. A value-engineering effort was initiated in an attempt to simplify and reduce the cost of the PEPC line-replaceable unit (LRU) and controls

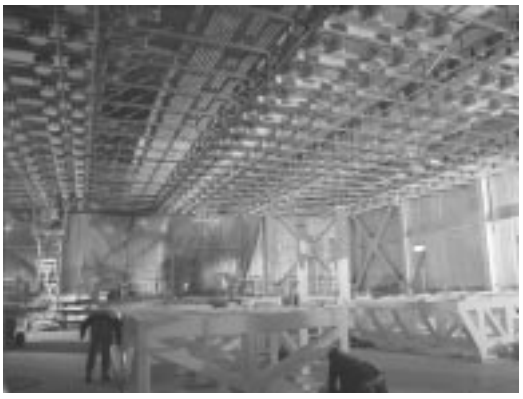

FIGURE 2. Optics Assembly Building interior, showing special equipment installation at floor level and duct work at the ceiling level. (40-60-1198-2279#15Apb01)

hardware. Several cost-reducing and reliability-enhancing features have been evaluated on the prototype cell during the past quarter. Examples include a smaller, lower-cost vacuum pump, circuit boards to mount electrical components on the LRU housing, a cold-cathode vacuum gauge to replace the hot cathode ionization gauge, and numerous improvements in the controls design and packaging. Procurement packages are currently being prepared for the PEPC LRUs for the first bundle.

- The primary focus of the power conditioning effort over the past quarter was validating the design of the power conditioning system module through testing of the first-article prototype at Sandia. Over 7000 shots have been accumulated to date. Data indicates that the module meets specifications when firing into the resistive dummy load, and simulations predict performance will meet requirements when driving flashlamps. The lifetime tests uncovered problems with the design of the commercially available energy dump resistor, which will be corrected in the NIF design. Analysis of the several catastrophic failures revealed problems with the design of the module enclosure. The design is being modified to contain any shrapnel associated with electrical faults, while reducing the pressure pulse contained within the enclosure. Capacitor qualification tests are now under way with samples from four suppliers. Tests have now been completed on at least five samples from each supplier.

Beam Transport System

Fabrication contracts proceeded into full production, and first deliveries of finished structures have arrived at LLNL. The Switchyard 2 structure contract was awarded, and the Laser Bay concrete request for proposals (RFP) was released for bid. In the next quarter, a convoy of truck-borne structures and vacuum vessels will begin to arrive at LLNL and occupy the staging areas. Remaining design activities are nearing completion. The intensity and level of detail of installation planning will continue to increase.

- Production and shipment of all spatial filter stainless plate is complete. Vacuum vessel fabrication of end vessels is proceeding at Ranor. Fabrication and welding of the first four vessels is complete and awaiting the start of machining. Fabrication of weldments is progressing on schedule with the next group of four vessels. Stadco work on the center transport spatial filter (TSF) has the first vessel in machining and the second vessel in finish welding. The first vessel completion is expected in March, and the final unit is scheduled in late May. March metal work on the center cavity spatial filter (CSF) has the first vessel at Allied for machining, and the second vessel is in final welding.
- Initial design development and detailing is complete on the Laser Bay interstage docking frames of the spatial filter (SF) end vessels. Engineering review and design checking is progressing with the assistance of personnel from the newly integrated Infrastructure Group. Completion of design, engineering, analysis and specifications is in progress to support procurement review and release in February.
- Review of the drawings for the Vacuum System was completed, and required changes are in progress. It is expected the drawings will go into PDM by the end of February. Development of the Beam Transport System vacuum control screens has begun.
- Tests were completed on a method of precisely controlling pressure in the amplifier slab cavities. This method used weight balanced on top of a flexible bellows to maintain even pressure. Results showed that there is too much spring in the bellows to meet the delta-P requirements. Test equipment is being retooled for another candidate method.

- The Switchyard 2 structure procurement RFP was issued for bid. All prospective contractors attended a prebid conference and construction site visit at LLNL. The contract was awarded in December to AGRA Coast Ltd. in Vancouver, BC. The design team is now continuing on Switchyard 1 drawing details. Switchyard 1 is similar, but not identical to Switchyard 2. A completely new set of drawings is required, equivalent in size to the Switchyard 2 set.
- The Laser Bay concrete pedestal support structure design drawings and analyses are complete. The specification is completed and has been incorporated into the bid package that has been sent out to the bidders. A bidders site visit has been scheduled for January. Trial assemblies were accomplished on all power amplifier lower structures, which were subsequently shipped to LLNL.
- The transport mirror mount design validation team made good progress toward resolving the Title II action item regarding the mounting-induced wavefront effects of transport mirrors. Preliminary analysis of a new design approach was completed in October. Hardware for the new design was received in mid-November; and assembly of the test mirror in the mount began. Testing of the new mount then began in December The effect of gravity- and mount-induced aberrations (predicted from detailed finite-element analysis) on propagation for six beamlines was assessed. The combination of finite-element analysis and beam propagation analysis indicates that the new design will meet the requirements for laser system performance. The interferometric measurements under way are intended to validate the finite-element analysis. Preliminary results are encouraging, but show discrepancies that are not fully understood. Additional on-line and off-line tests were done in late December (and planned to continue during January) to resolve these discrepancies.

Integrated Computer Control System

All baseline Title II design reviews, concluding with the 100% review of the Integrated Timing System in December, are complete. "Nightlight," the first of seven planned incremental releases of control system software, is complete. Nightlight was a confidence builder. The engineering team felt that they gained crucial experience and that the release successfully met planned goals. Independent testing of the software has also been completed. Sixty-nine test incidents were reported, of which twenty-one are categorized as software defects; the testing program is proving its worth at improving the quality of NIF software. The contract for the design and fabrication of the timing distribution subsystem was placed.

- Seven incremental releases of software (the "Light" series) are planned during NIF construction. A repeatable engineering process is used within each stage to ensure that the product is being correctly built and meets requirements. To begin the cycle, a portion of the product's requirements is selected for implementation. Each release will be measured against this documented set of goals. As the release is delivered, a demonstration is held, and the source code is placed under configuration management. The software is then subject to a 6-week period during which it is formally tested by the independent test team, which also provides for "ad hoc" testing by additional users. Defects that are found result in test incidents that are traced to determine the root cause. A thorough assessment of results and the engineering process is made and documented by the implementation teams. Targeting specific goals, a software implementation plan is written for the next release, which also estimates work needed in future increments. Measurements are taken on the source code, package count, and number of public methods in order to assess software complexity and rate of progress. Using this incre-

mental process, a new part of the NIF software is delivered about every six months. After each release, the results are analyzed to determine corrective actions.

- The Nightlight software delivery and test are complete. In a few cases, some software tasks were deferred until the next release so that assessment and planning for Penlight could be completed for maximum benefit. Nightlight testing goals were to verify that planned features operate as expected, to establish an independent test process, and to develop the repeatable processes by which the development and independent test teams could effectively work together. Nightlight established testing activities consistent with industry standards, including: test readiness reviews, implementation of a test incident tracking system, adoption of standard software defect severity levels, standardization of documentation methods for test procedures and checklists, and configuration management of test products such as procedures and results.
- The planning process for the second release of the Penlight software was completed, culminating in reviews of the software applications and supporting frameworks. A detailed planning document was prepared that contains a review of the Nightlight release followed by sections describing each application subsystem and a section covering the supervisory framework. In addition, the plan coordinates device support, controller support, graphical user interfaces, database coverage, and framework coverage.
- A procedure for informal code walkthroughs (a line-by-line review of software) was developed after a pilot effort was completed late last year. The primary purposes of the walkthroughs are early error detection, promotion of a team programming style, and dissemination of techniques. The procedure involves assigning two or three people as reviewers, having reviewers meet informally with the code developer, and using a simple, but managed, reporting mechanism.
- Automatic alignment software demonstrated concurrent alignment of 96 beams using software to emulate the time required to execute every controlled action. Under the normal conditions emulated (i.e., no commanded actuator failed to perform its nominal requirement), the entire 96-beam laser completed alignment in just over 11 minutes.
- The video front-end processor (FEP) delivered for Nightlight exceeded performance goals of three simultaneous streams of video, each at 10 frames per second. The performance of the newly coded Ada software exceeded the C language prototypes even though the new code is object-oriented. These results help allay concern that object-oriented software might not have adequate performance over past approaches.
- The 100% review of the integrated timing system was completed in December. The meeting went very well and included a presentation by the target physics users that concluded the timing system specifications will lead to a system that can meet NIF performance requirements.
- In the integrated safety system, life testing of the fiber-optic permissive transmitters and receivers to be used in the capacitor bays has made good progress. The units have currently completed over 20,000 simulated charging cycles.
- A new version of programmable logic controller communications software was obtained from Rockwell Software that was directed at fixing a previously reported incompatibility problem. Initial testing of this version indicates that the problem has been resolved.

Optical Components

Optomechanical Systems. Emphasis in all areas has shifted to preparing procurement packages and awarding contracts for first-bundle hardware. Awards were made for fused silica blanks for polarizers and

lenses for the OPG system, the CSF lens cassettes, and major procurements for the line-replaceable unit (LRU) assembly verification system.

The team assembled to resolve the optical mounts action item regarding validation of the transport mirror mount design made good progress. The specification of optical components for the OPG optical system was completed in December (48 optical component drawings). The 100% review Title II Design Review was held in November.

- The optical component drawings are awaiting check-off in Sherpa (the DOE/OAK Performance Measurement Mile-stone will be completed in January). Subsystems include the fiber launch/ regenerative amplifier and multipass amplifiers (both are part of the PAM), the input sensor telescope, the 1:4 split, the preamplifier beam transport system, and the injection system. This accomplishment resolves a previously reported problem.
- Excellent progress was made on the redesign and documentation of the preamplifier beam transport system (PABTS). The main part of this design is a six-element, adjustable telescope to accommodate the various path lengths, timing, magnification, relay plane, and collimation requirements of the part of the system just prior to injection in the TSF. The nominal configuration required for the OPG demonstration has been specified; final analysis and specification of the configurations and sensitivities for the other bundles are in progress.
- The 1ω and 3ω diagnostic relay telescope systems (eight per bundle) were redesigned for lower cost. The new designs have fewer elements but more aspheric surfaces. In addition to reducing cost, these new designs greatly simplify the ghost and stray light management for the system.
- The Title II design review was held in November for the KDP crystals. The review focused on the ability of rapid and conventional KDP growth to meet performance specifications and progress towards facilitization and demonstration of the KDP finishing equipment and processes. The reviews demonstrated that DKDP (deuterated) grown by conventional growth meets third-harmonic laser damage specifications and that rapid-growth processes can produce KDP of the size and quality required for Pockels cells and second-harmonic generators. There were no significant issues raised during the review.
- Castings of first-cluster polarizer material occurred in November with an expected delivery of annealed and shaped parts at the end of FY99. The first-cluster BK7 transport mirror material was ordered in December. The material will be stored at the vendor's warehouses in the United States until the blanks are needed. Pilot material for first-bundle laser mirror LM3 is currently being formed and shaped with the first set of blanks sent from overseas in December.
- An evaluation of the suitability of the current sol coating process for production of the NIF 1ω diagnostic beam-splitter reflecting surface was completed. The analysis indicated that current coating materials and practices will likely meet NIF requirements.

An ammonia-treated spatial filter (SF7/input) lens was installed in a Nova beamline. This lens is a full-scale demonstration of a hardened and passivated coating in relatively high fluence. Closure on this experiment will come with removal and evaluation of the lens coating properties at the shutdown of the Nova laser later in FY99.

Laser Control

Preparations and presentations for all remaining 100% design reviews were completed. Prototype testing began to pay off by validating performance in some cases and identifying areas for improvement in others. Vendor qualification activities increased at the end of the quarter in preparation for scheduled procurement requisitions. Completion of detailed drawing

packages to support the procurement schedule is currently the largest challenge.

- All first-bundle build-to-specification components for the TSF alignment tower are in fabrication or procurement except for a translation slide requiring manufacturer design modifications and fiber-optic splitters and collimators. Requisitions for these items will be sent to procurement early in the next quarter. Life testing of a commercial positioner for the TSF diagnostic tower showed that longer life limit switches must be incorporated. The build-to-specification procurement package for the diagnostic tower is being held until the positioner vendor makes an appropriate substitution. Detail drawings for build-to-print components on all tower platforms are scheduled for completion in the next quarter.
- The input sensor was assembled, and most of the sensor test stand components were also received. In addition, the hardware and software for running the input sensor motors and shutters were completed. Testing is expected to begin near the end of January. Characteristics of the turning mirror that transmits approximately 1% of the PAM output beam to the input sensor were measured as a function of humidity. Significant transmission variation in the relative humidity range between zero and about 35% suggests that the operating atmosphere for this optic must either be carefully held at near-zero humidity (dry nitrogen, for example) or in the 40±10% range to avoid unacceptable changes in the input sensor energy calibration.
- Instrumentation for measurement of optical coating properties was designed, assembled, and applied to key components. Effects of contamination on sol-gel coatings for diagnostic beam splitters and the stability of antireflection (AR)-coated, beam-sampling gratings in a vacuum environment were among the properties measured. The grating sample efficiency was found to change by 25% over an eight-hour period when the test volume was evacuated. This behavior will be studied further, but measurements so far strongly suggest that an uncoated sampling grating may be required.
- Fibers received in November from Vavilov Institute were tested for dispersion and attenuation at 350 nm. The 10-m sample of large core, 435-μm-diam fiber was found to have low dispersion as the Russians claimed, but a longer sample is required for an accurate measurement. A change of deliverables for the second half of their current contract was proposed to Vavilov so that a longer sample can be provided. If successful, a single, large-core fiber could replace an entire 19-fiber bundle. A recent sample of 100-μm core fiber was also tested and found to have high attenuation, 400 dB/km as compared with the predicted 150 dB/km. This discrepancy will be pursued.
- The two vendor-produced deformable mirror prototypes were both retested after repairs by their respective companies. In both cases LLNL personnel participated in some aspects of the repair work. The testing of one of the rebuilt mirrors was completed in December, and it was declared performance qualified, because the test results were essentially indistinguishable from those of the LLNL prototype mirror. However, some concerns about reliability remain. Testing of the other vendor prototype began right before the holidays and is continuing into January. Initial indications are that performance will fall short unless additional changes are made.
- The Nightlight prototype version of wavefront controller software was released after internal testing in the wavefront laboratory as part of closed-loop operation of the prototype deformable mirrors. After release, the

controller was tested by the independent software-testing group, and no defects beyond those already identified in the laboratory were found.
- Full beamline propagation modeling including complete measurement-based models of the prototype deformable mirrors has become a mature tool for system optimization. During the quarter, the latest estimates of pump-induced aberrations and gravity and mounting aberrations for switchyard mirrors were added to the baseline propagation model. The model was also used to perform wavefront correction sensitivity studies with actuator spacing and beam alignment error as variables. These studies showed that a 5% increase in focused energy in the target chamber could be obtained by a small reduction in actuator spacing and that the resulting increase in sensitivity to alignment error was negligible. This improvement, the energy equivalent of adding nine complete beamlines to the NIF, is the direct result of achieving a convincing wavefront system modeling capability.

Target Experimental Systems

The majority of target chamber subsection welding was completed in the first quarter 1999. The vacuum chamber seams were welded at the LLNL site, see Figure 3. Precision Components Corporation continued to fabricate the weld neck ports.

In Place Machining Corp. has completed and demonstrated a final mockup of the equipment that will be used for boring the holes in the chamber. The machines will use two single-point tool bits that are hydraulically driven.

- The target chamber move date has been changed from March 25, 1999, to June 1, 1999, and the chamber leak check will be performed while the chamber is in the fabrication building. This cuts the Pitt-Des Moines Steel downtime, or Target Building stay-out period, helping Pitt-Des Moines Steel complete the target chamber on schedule, and provides better weather and drier ground conditions for crane site preparation and the target chamber move.
- The analysis of the beam-dump prototype placed on Nova was nearly complete in November. The data reduction and analysis for the titanium samples was completed. As preliminary results indicated, there were no showstoppers. The stainless-steel louvers perform well for both first wall and beam dumps. X-ray fluorescence tests were performed on the Nova contaminated fused silica samples, and the results coordinated well with the damage tests performed on the optics. The results of this work also did not indicate problems with the stainless-steel louvers for first wall and beam dumps.
- The target positioner changes have been completed to eliminate the separate carriage to which the graphite-fiber–reinforced composite boom was to be attached. This will make the boom a single unit with the mounting pads for the linear bearings extending from hoops bonded to

FIGURE 3. Target chamber with temporary ties holding the 18 plates together prior to full welding. (40-60-1298-2447#17pb01)

the boom with an intermediary electrically insulating layer. Changing the double-walled vacuum vessel to a single-wall vessel having the same cross-sectional moment of inertia is nearly complete. This redesign required changes in the linear rail beds and track mounting beams and allowed improvements to the ball screw intermediate supports.

- The interface control document (ICD) for the Diagnostics Data Acquisition System (DAS) cable definition has been completed. The interface definitions in the ICD are done but final cable determination is not available at this time. The design is currently at the 35% level. The standards and guidelines document is presently being revised to include the preliminary Diagnostic Communication Protocol (DCP). The DCP will be the communications interface between the diagnostic controller and the FEP. The DCP messages and their required arguments have been defined, and preliminary DCP application interfaces should follow soon. Software goals for the Penlight version of the Target DAS FEP have been delivered for publication in the Penlight Software Implementation Plan. Work on a Connection Manager daemon is continuing. Ada packages to write a log file for the Connection Manager and time-stamp log file entries are complete. Currently, an Ada package to read and parse a configuration file is under development.
- It has been decided that existing Nova diagnostics will satisfy the Diagnostic Instrument Manipulator (DIM) laser verification experimental requirements. These are the gated x-ray imager and the six-inch manipulator-based streak camera. The resources that were planned for these two diagnostics will be redirected toward the work required to finish the design of the DIM. Design continues on the control and signal cables to support various target configurations on the front end of the target positioner. The mechanical design of the carriage and boom assemblies is changing from two mating components to a single composite assembly that will be more rigid. This new design will have some impact on the attachment of the cable tracking system but will not affect the schedule.
- Design changes are being incorporated into the mirror frames as a result of meetings with several fabricators. These modifications will help reduce the component cost.
- The design layouts for the retractable and removable beam tubes for the lower level that are adjacent to the floor in the upper and lower mirror rooms have been prepared and will be reviewed by the infrastructures and operations groups before proceeding with detailed design.
- Work has been delayed on the tritium environmental protection systems until 2004 to be able to prepare for the introduction of tritium into the facility in 2005. The exception to this delay is the stack monitoring system, which will be in place for the first bundle.
- The 100% review Title II Design Final Optics Assembly (FOA) Review was held in November. The review had been delayed by approximately one month to allow more time for scientific review of the last Beamlet tests using the final optics cell (FOC). The following topics were included in the review: physics overview, subsystem reviews (FOC, integrated optics module, actuation system, debris shield cassette, vacuum isolation valve, 3ω calorimeter chamber, thermal control system, vacuum venting system), and prototype testing results.
- Preparations proceeded well for first-article procurements of the integrated optics module (IOM), the FOC, and 3ω calorimeter chamber. The detail drawings for the IOM are complete and awaiting check. The FOC drawing package was released under Configuration Management.

Operations Special Equipment

Title II design is proceeding well. This has been a productive quarter with FY99 budget planning process, intensive detailed design continuing, and fast-track prototyping and testing going well in the support laboratory. Several key internal milestones were completed.

- The alpha prototype release of the Operations Special Equipment Controls Supervisor (OSECS) was completed and demonstrated in December in Bldg. 432. The alpha prototype is the first vertical slice of OSECS and implements the Transport and Handling (T&H) cover removal operation for the Top Loading (TL) delivery system. The subsystems included in this release are the supervisory software module and the TL supervisory graphical user interface, both implemented in Java using CORBA, and the TL safety interlock system. The acceptance test procedures for this release have been completed, and the testing will be conducted in January. The detailed design of the Laser Bay Transport System (LBTS) interfaces with OSECS was completed, and the vendor (AGVP) is proceeding on schedule with their software development tasks.
- The detailed design for the Bottom Loading (BL), TL, and Side Loading delivery systems is progressing. The T&H team met with the Optics Assembly Building (OAB) team and discussed the OAB docking port requirements versus the existing design. The decision was made to switch the two docking port (universal and amplifier) locations. The amplifier docking port will now be located closer to the elevator. This will allow the canisters to dock to the OAB without rotating the canisters after a line-replaceable unit (LRU) is inside.
- The design effort for the BL Amplifier Slab Delivery System continues. The primary concentration was on the cover removal mechanism and docking mechanism for the system. A peer review of this system was completed this quarter. All interface partners were in attendance at this review. One of the prototype NIF frame assembly units will be available for testing of the LRU insertion/removal process. This testing is scheduled for December 1999.
- Fabrication of the hardware for the LBTS is continuing. The frame is being fabricated at Alkab, Inc. The majority of the parts that make up the weldments have been machined. Welding of the parts has begun, and AGVP is on schedule and ready to receive the transporter from RedZone.
- Detailed optical assembly and alignment design, prototyping, and procurement are progressing, with most of the prototype equipment now procured, and Phases II and III of OAB installation are complete. Special equipment installation into the OAB was completed in November. Those systems include optic insertion pedestals, Ergotech supports, and granite final supports. Jib cranes for airlocks and BL and TL docking ports were also installed in the OAB. An intensive acceptance test was completed in December for vertical and airlock lifts, and then installation into the OAB followed. Special equipment that will go inside the OAB and mount onto the raised floor is still being specified and procured.

Start-Up Activities

Overall progress was good. Integrated computer control system (ICCS) Nightlight testing was successfully completed, planning was initiated for OSEC Alpha release testing, and preparation of detailed test flows and test summaries for several priority areas of the Project continued in support of the Master Test Plan development effort.

- Two test plans were generated by the NIF independent test team (ITT): one for the ICCS Nightlight release (NIF-5001097) and one for the OSEC Alpha release (NIF-5001272). Several key test processes were established and demonstrated during ICCS Nightlight release testing. These processes, consistent with industry standards, included use of standard documentation methods and electronic review/approval for test plans and procedures, test readiness reviews, release of software to the ITT under configuration management, adoption of standard software defect severity level classifications, creation of an electronic test log and test incident tracking database, and configuration management of test products such as test procedures and summary reports.
- Tests and demonstrations were completed for all thirteen ICCS Nightlight slices. Overall, software quality was found to be good. A total of 21 software defects were identified, and 20 software enhancements were recommended for development staff consideration as a result of formal testing by the ITT and ad hoc testing by Nova operations personnel. All software issues have been converted to software change requests (SCRs) and are being tracked by the development team. A summary test report (NIF-5001322) was prepared and issued for approval and release. A test procedure is being prepared by the ITT for the OSEC Alpha release.
- To facilitate development of the Master Test Plan (MTP), the NIF system was broken down into approximately 40 "subsystems," and points of contact were assigned from the NIF Operations team to begin investigating test plans being developed by the lead engineers and their support personnel for all high-priority areas. Information collected is being documented using test flow diagrams and test summary spreadsheets, and these products will form the basis for the MTP. To date, preliminary test flows and spreadsheets have been completed for 15% of the subsystems (PAM, injection optics, spatial filter LRUs, transport mirrors, PEPC, and deformable mirror), and another 25% are in progress. In addition to individual subsystem test plans, development of the sequence for subsystem integration was initiated. This effort is approximately 35% complete. A draft outline for the MTP was prepared and issued for review and comment.
- A preliminary plan for a system-wide Component Installation Plan has been prepared. It is initially a series of connected boxes representing cleaning, packaging, transport, or cleanliness validation steps necessary for each NIF subsystem. Each cleaning process is represented by a specific procedure. Creation of these Component Installation Plans will identify similarities as well as conscious differences between subsystems. The identification of similarities will help to ensure that similar subsystems are cleaned by similar processes, using similar equipment and vendors, and are validated to consistent standards. The common processes for cleaning and validating the cleanliness of subsystems identified during the construction of the Component Installation Plans will be documented in engineering procedures referred to as Mechanical Engineering Letters (MELs). Sixteen of the documents have already been written and a few have reached a stage of maturity in which they have been put under configuration control. The contamination control team presented a status report entitled *Organic Cleanliness and Effects on Sol-gel Coatings and Aerosol Generation Status Report* in December. This review completed the major work on organics and their effect on the transmission of sol-gel coatings. The conclusion is that all vacuum com-

ponents need high-pressure or ultrasonic/Brulin washing; elastomers need bakeout at 170°C; and all nitrogen and argon-filled components will be high-pressure or ultrasonic/Brulin washed to protect sol-gel coatings from >0.1% transmission loss in 1000 hours. The status of cleanliness control process maps in support of the systemwide Component Installation Cleanliness Plan was reviewed in December. The discussion included the cleaning process selection chart, components for which specific cleanliness plans are required, and rules for preparing the process flow maps. The status of the flowcharts will be reviewed again in February 1999.

- A baseline approach for a laser operations model has been defined, largely using parts of existing propagation code, BTGain. Interfaces of this model with operational and optics databases, as well as the NIF ICCS, have been explored. A preliminary effort analysis to implement this model has been completed and will be used to decide on an action plan.
- The final revision of the FY98 operability model report was issued. This included incorporation of review comments from the initial release. The model results were presented as part of the NIF RAM and Operations Modeling Assessments Review held in October.

ES&H and Supporting R&D

Assurances. Key Assurance activities during November to support the Project included: construction safety support, QA procedures, audits, and surveillance planning, and preparation for upcoming independent external audits (DOE OAK, Independent Project Assessment). Other activities included: litigation support to the DOE for the settlement of 60(b) (e.g., quarterly reports), the overall litigation against the *Stockpile Stewardship and Management Programmatic Environmental Impact Report*, interface with the Institutional surveillance for buried hazardous/toxic and/or radioactive materials, *Final Safety Analysis Report* preparation, and support for environmental permits and the *Pollution Prevention and Waste Minimization Plan*. All are on schedule.

- The Congressionally mandated Independent Project Assessment is due to begin in January 1999. The proposed presentation material and supporting documents were prepared for the Project Manager's review. The DOE Field Manager has provided the proposed Task A review agenda from the Independent Project Assessment Team. In a related action, the Management Position Descriptions were updated completly and are being edited for the Project Manager's approval.
- The paleontological finds were previously accurately located and reported to the University of California Museum of Paleontology. In December, these bones were carefully covered with sand and then a marker level of gravel. The covering was witnessed by a representative of the Environmental Protection Department.
- Elemental analyses have been completed for the first significant neutron shielding concrete pours in the Target Bay. The results show significant, but manageable, levels of impurities. Activation calculations have shown that the shielding meets the design criteria and specifications. Future Target Bay concrete pours will be sampled as well to ensure continued compliance with specifications.
- The DOE Oakland Annual Management Assessment was completed in draft form and factual comments returned to the assessment team. The report will be issued in January 1999.

Optics Technology. Facilitization is all but complete at Hoya and Schott with all contracts placed and pilot activities

already started. Hiring and training for pilot runs is mostly completed. Both laser glass vendors are doing a great job in supporting the NIF schedules.

The Zygo facility was completed in the first quarter 1999, and first-bundle optics (LM3) are now being shaped. Spectra-Physics has completed all major facility work and is in the process of installing equipment, such as the clean line. Currently Spectra-Physics is in the process of installing the new planetary, conditioning stations, and preparing the interferometer area for installation of the new interferometer in the second quarter. The Laboratory for Laser Energetics (LLE) at the University of Rochester has completed the coating and cleaning facilities and is near completion of the metrology facilities that will also be completed in the second quarter.

- The Schott laser glass grinding and polishing has been installed with assistance from Zygo Corporation, and initial results look very good. The flatness specification and process flow time should not be an issue. All fine annealing ovens have been delivered and set up.
- At Hoya, full-scale furnace and lehr are complete. Hoya is still on schedule to start the Laser Glass Pilot run mid-January 1999. Two 120" Lapmaster grit grinder and polishers have been delivered and set up. First-bundle laser glass cladding strips were produced in Japan and delivered on time.
- Six 1000-L crystallizers continued to operate at LLNL. A KDP boule was grown to a size that will yield nearly 20 Pockels cell switch crystals. The two DKDP crystals, one horizontal and one vertical, continued to grow without significant problems. A mathematical model was formulated and tested for the leaching of impurities from the growth tank and their incorporation into the boule.
- Corning has completed the debugging of all facilitization equipment including the boule/blank extraction saw, 84" Blanchard, overarm lapper, 24" Zygo interferometer and fixturing. Pilot production of NIF fused silica blanks has begun. All process and quality assurance procedures have been reviewed and approved by LLNL. The first optics were shipped to Tinsley in December.
- Tinsley's lens and window finishing facility building was completed on schedule, and beneficial occupancy was obtained in November. Most manufacturing equipment was installed into the new building. A few pieces of equipment remain to be installed. They are expected to be installed prior to the optics being ready to be placed on those machines. The facility has been made ready for start of pilot production. Early pilot production of NIF optics has continued at Tinsley. The first three of seven focus lenses are nearing completion. They will be available for ultraviolet laser damage testing in February. The finishing of two cavity mirrors and two debris shields is still in process. Main pilot is scheduled to award at Tinsley in January. Work has begun under the Flexible Finishing Facility contract awarded to Kodak in late September, and LLNL has begun receiving the Kodak Monthly Progress Reports and detailed schedules. All LLNL or government-furnished equipment (GFE) has either been ordered or already received at Kodak. The Pilot Production Option associated with the Kodak Flexible Finishing Facility contract was exercised and awarded during mid-December.
- The automated aqueous cleaning systems from JST Custom Fabrication were completed and ready for delivery to LLNL at the end of December. Chemat Technology Inc. has completed approximately 80% of the mechanical assembly and control software development on the sol dip-coating system.

- Zygo facilitization is complete, and shaping of first-bundle optics has begun.
- The LLE 54" planetary design was completed to allow coating of only NIF optics in the 72" chamber and Omega optics in the 54" chamber. The metrology facilities are under construction. All of the major re-modeling work is complete, but utilities and high-efficiency particulate air (HEPA) filter installation need to be completed. LLE conducted an experiment with an in-situ interferometer to examine the surface flatness of an optic during heating and cooling to improve their model of the appropriate rapid cooldown cycle. This work will also aid in understanding reflected wavefront distortion due to coating versus other contributions.
- Spectra-Physics received beneficial occupancy for the remaining facility in November, contingent on some minor fire sprinkler relocations and landscaping issues. The metrology labs are starting to be populated with equipment. The Large Area Conditioning Station assembly started in December. The isolation pad for the interferometer was sealed to prevent humidity penetration into the dry enclosure, and the vibration isolation table was installed.

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